

## SIMPLE MODEL REPRESENTATIONS OF TRANSPORT IN A COMPLEX FRACTURE AND THEIR USE IN LONG-TERM PREDICTIONS

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### RESEARCH OBJECTIVES

A complex fracture model for fluid flow and tracer transport was previously developed that incorporates all the important physical effects of a complex fracture zone. These effects include advection through a heterogeneous fracture plane, partitioning of flow into multiple subfractures in the third dimension, diffusion and sorption into fracture-filling gouge, small altered rock matrix blocks within the fracture zone, and the unaltered semi-infinite rock matrix on both sides of the fracture zone (Tsang and Doughty, 2003).

It is common, however, to represent the complex fracture by much simpler models consisting of a single fracture, without subfractures and with only the unaltered semi-infinite rock matrix for diffusion and sorption. The fracture may have a uniform (homogeneous) or heterogeneous transmissivity distribution over its plane, bounded on both sides by a homogeneous semi-infinite matrix. The parameters of the simple model can also be taken from laboratory data or calibration to short-term site-characterization (SC) data. The question posed by the present research is, how adequate are these simplified models for long-term performance assessment (PA) calculations that cover thousands of years?

### APPROACH

We use a particle-tracking approach to calculate tracer transport in a complex fracture model, incorporating all the features described above, for a one-day SC tracer test and a 10,000-year PA prediction calculation. The results are considered the "real-world." Next, two simple fracture models, homogeneous and heterogeneous, are introduced. Properties for these simple models are taken either from laboratory data or found by calibration to one-day SC tracer-test breakthrough curves (BTC) obtained with the complex fracture model. Then, the simple models are used to simulate tracer transport at the PA time scale.

### ACCOMPLISHMENTS

First, the results from laboratory-measured parameters are compared with those when data from the one-day SC tracer tests are used. The BTCs from the two cases are quite different, but by adjusting model properties, the simple models can reproduce peak arrival time and height. The overall match, however, is still poor (left frame of Figure 1).

Second, using simple models with SC-calibrated parameters for PA calculations causes order-of-magnitude errors in

tracer BTCs: peak arrival time is 10 to 100 times too late and peak height is 100 to 1,000 times too small (right frame of Figure 1). On the other hand, using simple models with laboratory-measured properties of unfractured rock samples for PA calculations also produces erroneous results: peak arrivals and heights can be up to a factor of ten too early and high, respectively (right frame of figure). These are not general conclusions, since they depend on the parameter values assumed for the complex fracture model, and thus are more illustrative in nature, indicating the need for careful consideration.

### SIGNIFICANCE OF FINDINGS

If a simple heterogeneous or homogeneous fracture model is used to predict tracer transport for a complex fracture at PA time scale, large errors may arise no matter what method is used to determine model properties. A remedy may be to determine properties by calibration to longer-term tracer tests (one to a few months rather than one to a few days), which will be sensitive to the detailed complex fracture features. A paper describing this work is in preparation.

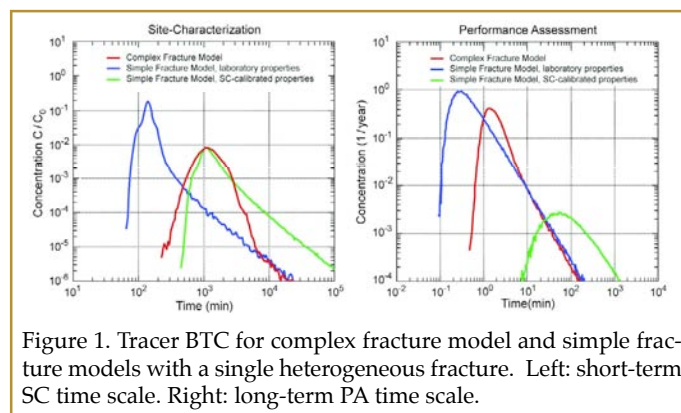


Figure 1. Tracer BTC for complex fracture model and simple fracture models with a single heterogeneous fracture. Left: short-term SC time scale. Right: long-term PA time scale.

### RELATED PUBLICATIONS

Tsang, C.-F. and C. Doughty, A particle-tracking approach to simulating transport in a complex fracture. *Water Resour. Res.*, 39(7), 1174, doi:10.1029/2002WR001614, 2003.

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